Cir 315
AN/179

Hazards at Aircraft Accident Sites

Approved by the Secretary General
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International Civil Aviation Organization

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INTRODUCTION

1. During the Accident Investigation and Prevention (AIG) Divisional Meeting in September 1999, it was agreed that ICAO had a role to play in establishing and maintaining an inventory of hazards peculiar to aircraft accident sites and in the promulgation of related guidance material to States. The meeting noted that the development and updating on a regular basis, of a list of accident site hazards, was essential. The meeting also agreed it was necessary to specify the training required for accident investigators to enable them to avoid these hazards. Based on the meeting's discussion, ICAO developed a study group, to be known as the Hazards at Accident Sites Study Group (HASSG). The study group was to compile a list of hazards peculiar to aircraft accident sites, develop relevant guidance material and determine the associated training requirements for rescue personnel and accident investigators.

2. In response to the proposal, ICAO established the HASSG to develop the guidelines contained in this circular. ICAO acknowledges that these guidelines are evolutionary in nature and may need to be updated periodically. Working at aircraft accident sites has the potential to expose investigators, and search and rescue personnel, to a wide range of health and safety hazards. These hazards, generated by the damage to structures, systems, components and aircraft contents, will be variable in nature and will themselves be influenced by the factors associated with the accident scenario, e.g. location, weather conditions, environment, security, etc. To protect investigation and search and rescue personnel requires the application of a system of safety management that identifies the hazards present, determines levels of exposure, assesses the risks posed, and introduces effective measures to eliminate or control exposure. Given the unpredictable character of air accidents, the task of applying an effective safety management system can be both demanding and complex.

3. This circular is produced to assist individuals to consider and apply effective occupational safety management practices both to their own activities, and to the activities of the teams that they work with, or for which they are responsible. The circular discusses the nature and variety of occupational hazards, and the management of risk associated with exposure to these hazards.

4. Throughout this circular, with the exception of the definitions in Chapter 1, the use of the male gender should be understood to include male and female persons and the term "accident" should be understood to include "incident".

5. ICAO is grateful for the considerable assistance provided by members of the Hazards at Accident Sites Study Group in the preparation of this circular.

6. Links to web sites from aircraft manufacturers providing information on aircraft hazardous materials can be found on the ICAO Flight Safety Information Exchange website at www.icao.int/fsix/res_aig.cfm.

Chapter 1

TERMINOLOGY

The definitions below are given to ensure that the readers understand the intended meaning of the terms in the context of this circular.

Accident investigator. A person engaged in the investigation of aircraft accidents, incidents and other aviation safety hazards.

Asphyxia. Suffocation as a result of physical blockage of the airway or inhalation of toxic gases.

Dynamic assessment. Factors associated with the specific accident – accident location, specific details of damage sustained, occupants, cargo, fuel load, time of day, etc. that are used to generate an indication of the risk existing at a specific point in time.

Generic assessment. Background information available to all to assist with considering what hazards are likely to be present – aircraft type, age, modification standard, operating category, typical damage, pre-identified hazards, sampling and analysis data. Enables organizations to plan and prepare, train and establish levels of support equipment.

Hazard. Something that has the potential to cause adverse consequences in terms of harm and/or damage.

Investigation. A process conducted for the purpose of accident prevention. It includes the gathering and analysis of information, the drawing of conclusions, the determination of causes and the making of safety recommendations.

Investigator-in-charge. A person charged, on the basis of his or her qualifications, with the responsibility for the organization, conduct and control of an investigation.

Pathogen. An agent that can cause disease, such as a bacterium or a virus.

Pyrotechnics. The art of making and using fireworks.

Response personnel. Trained individuals responding to a distress by performing search and rescue functions, providing initial medical assistance, medical evacuation and recovery to a place of safety, through the use of public and private resources.

Rocket-deployed emergency parachute system. Whole-aeroplane emergency parachute systems.

Toxic. Relating to or containing a poison or toxin.

Vaccination. Inoculation with a vaccine to provide immunity against a disease.

Chapter 2

MANAGING OCCUPATIONAL HEALTH RISKS IN AIRCRAFT ACCIDENT INVESTIGATION

2.1 GENERAL

2.1.1 In the aviation industry, occupational health and safety systems have been developed over time to ensure that high standards of occupational safety are achieved for those involved in the manufacture, operation, servicing and maintenance of aircraft. These safety systems utilize well established processes to identify hazards, determine exposure, assess associated risks, and introduce effective measures to eliminate or mitigate these risks. The highly structured and repetitive nature of many aviation industry activities simplifies the task of safety management.

2.2 CHALLENGES

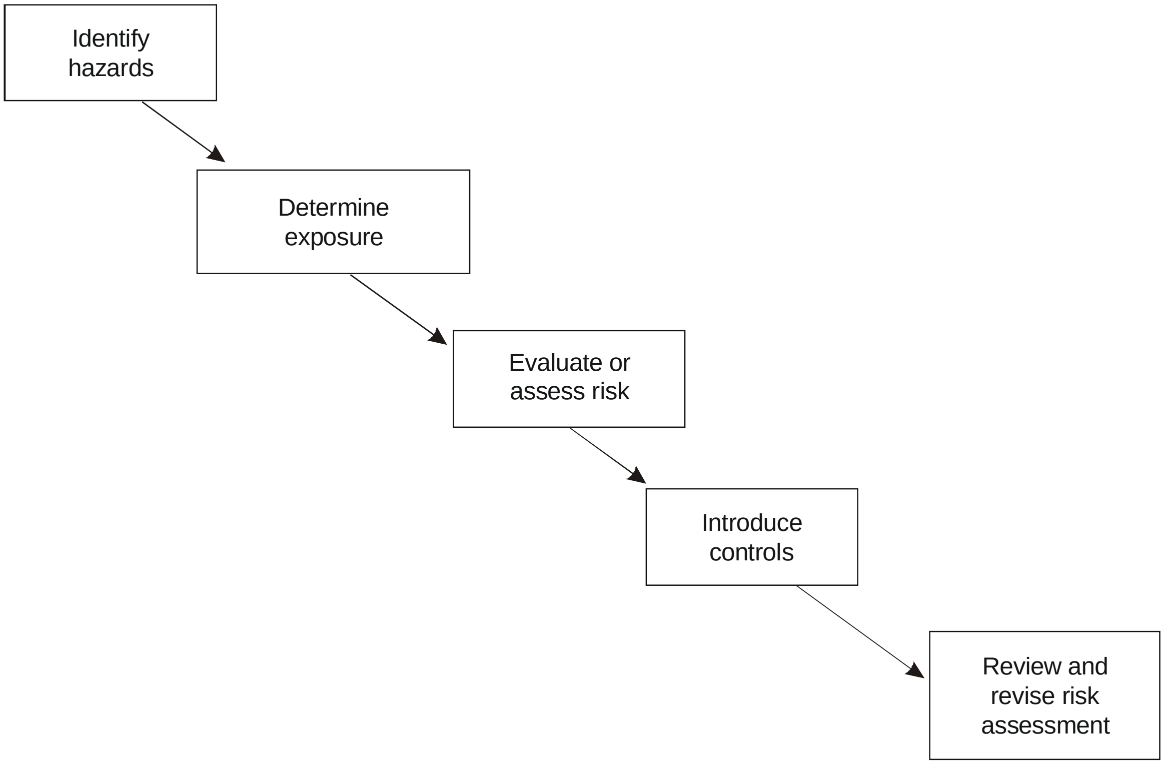
2.2.1 The application of safety management in the conduct of aircraft accident investigation operations is far more complex. There are a range of factors that have a significant effect on the safety management process. Unlike personnel involved in the more predictable domains within the aviation industry, investigators are required to respond to accident situations that are variable in nature, scale and environment. These factors make the identification of hazards and determination of exposure a more difficult exercise. Furthermore, given the relative infrequency of accidents, there are few opportunities for the scientific analysis of aircraft debris that is essential for accurate assessment of occupational health risks.

2.2.2 Many States have recognized the difficulties associated with managing occupational health and safety for accident investigators and have provided guidance for personnel in the form of documented policies and procedures. The guidance material provided varies between States, particularly in relation to the different legal systems in place internationally and in consideration of the varying range of research data available to organizations.

2.3 RISK MANAGEMENT AT AIRCRAFT ACCIDENT SITES

2.3.1 No activity can be absolutely free of risk, but activities can be controlled to ensure that risk is reduced to an acceptable level. If the risk remains unacceptably high, activities will have to be delayed or modified and a new risk assessment carried out. Often, a balance must be struck between the requirements of the task and the need to make the performance of the task safe for investigation and response personnel. This balance may sometimes be difficult to achieve but should always be biased towards safety.

2.3.2 The modern approach to the management of occupational health and safety recommends a process as follows:



2.3.3 This process appears rather simple in concept and, indeed, the process may actually be easily introduced for those process-based industries that benefit from sufficient knowledge, time and planning capacity and that have firm control over their operations. However, organizations with responsive roles, such as accident investigation bureaux, rarely have the opportunity to apply these resources even if they have access to them and this constraint, together with the variable nature and scale of aircraft accidents, frequently makes the management of risk a more complex process than this schematic model suggests.

2.3.4 Effective risk assessment first requires sound data to enable the **identification of hazards**. Chapter 3 provides details of some known hazards commonly associated with aircraft accident investigation. Sources of information such as maintenance manuals and hazard databases should also be used by investigation authorities in this process.

2.3.5 Identifying the groups of personnel who are likely to be exposed to hazards, the frequency of them being so, and the manner in which they will be exposed and, potentially, harmed is essential to properly **determine exposure**.

2.3.6 To evaluate and subsequently manage the risks inherent in accident investigation, there needs to be some degree of measurement applied in **assessing the risks**. For some activities, risks may be objectively measured, for example, in a situation in which exposure levels to chemicals are specified and exposure concentration is known. However, in other activities, including aircraft accident response, such measurements may not be possible, and there is no alternative to making subjective assessments of the level of risk. In any case, to make a reasonable assessment, response personnel need to determine specific information about the aircraft, its contents and the extent of damage. Equally important are environmental factors including weather, location and prevailing local conditions. A considered decision can then be made with respect to risk. If the task is considered too dangerous, it may be necessary to abandon the activity. Alternatively, the risk may be reduced by applying control measures.

2.3.7 **Chapter 4** suggests the use of an operational safety plan to assist with the management of activity at accident sites, including the assessment of hazards and risks and the application of control measures. It is important that organizations employ the services of suitably qualified/experienced persons for managing the occupational health and safety aspects of accident site operations. In addition, consideration should be given to providing access to qualified advisors to provide specialist guidance in high risk situations.

2.3.8 The need for prior planning and training cannot be overemphasised, especially during the initial investigation when critical accident information can be easily lost or contaminated. The collection of fluid samples from various systems is time critical, while haphazard collection of samples will cause contamination and provide misleading indication of system deficiencies. Flight control actuators, flap and control surface deflections and cockpit switch locations are all critical evidence that must be properly documented as rapidly as possible without causing additional hazards to the investigators.

2.3.9 A wide range of control measures can be applied to help reduce risks, including:

a) stopping or delaying the task – where risk is shown to be excessive, this may be the only option until alternative methods of work are established;

b) removal/isolation of hazards – components can be disconnected, made safe or removed from the site, hazardous materials can be neutralized or covered, dust and fibres can be suppressed with water or fluids, etc.;

c) limiting exposure – reduce the numbers of personnel within hazardous areas or limit the length of time or frequency of exposure;

d) modifying tasks or using alternative equipment or materials – this course of action can produce significant reductions in risk;

e) employing specific work procedures (e.g. exposure control plans); and

f) using protective clothing/equipment – see Chapter 4, Appendix B.

2.3.10 In addition to these on-site measures, effective organizations are likely to employ specially trained personnel who make good strategic use of information systems including medical and scientific networks and feedback systems.

2.3.11 Given the sometimes prolonged duration of accident site operations, assessments will need to be **reviewed and revised** frequently to take account of changes to weather, site operations, personnel, and other associated aspects.

2.3.12 Every opportunity should be provided to conduct training sessions and hazard analysis with air carrier operators and service providers in order to ensure the appropriate response to accidents and incidents. This relationship will enable the appropriate protection for emergency response personnel and accident investigators. The results and recommendations from these training sessions should be incorporated into inspector training and emergency response qualifications.

Chapter 3

HAZARDS

3.1 GENERAL

3.1.1 A hazard is something that has the potential to cause adverse consequences, and the degree of adverse consequences caused by specific exposures is important when determining the risk posed. A wide range of hazards may exist at aircraft accident sites, some of which may not be directly associated with the aircraft wreckage. Hazards may be posed by pathogens (from human or animal remains), cargo, and the nature of the accident location, ground installations, and other factors. Given the wide range of potential hazards at an accident site, it can be helpful to categorize typical hazards, in order to better manage the accident site.

3.1.2 Hazards have been categorized as follows:

Environment — location (both geographic and topographic), fatigue (effects of travel and transportation), insects/wildlife, climate, security and political situation;

Physical — fire, stored energy, explosives, structures;

Biological — pathogens associated with human remains or cargo consignments and state of local hygiene;

Materials — exposure to and contact with materials and substances at the site; and

Psychological — stress and traumatic pressures imposed by exposure to the aircraft accident, and interaction with those associated with the air carrier and related aviation activities.

3.1.3 When considering hazards, it is important to consider the manner in which they may be presented. Some hazards produced by acute events may result in a risk of short duration; these may be physically evident as, for example, fire, explosives, electrical discharges, lack of oxygen and chemicals. Other hazards may not be immediately observable but, through either single or multiple exposures, pose significant health risks over time. It is not unusual for hazards posing more immediate threats to be prioritized ahead of hazards threatening delayed symptoms, yet the hazards threatening delayed symptoms may eventually present a much greater degree of risk.

3.2 ENVIRONMENTAL HAZARDS

3.2.1 The ***accident location*** frequently poses a range of hazards to investigators due to the geographic and topographic location of the site. On land, the site may be located in remote or built-up areas, at altitude or in very difficult terrain; each of these may pose particular hazards. Marine situations can pose their own problems depending on whether the accident site is in shallow or deep water. Recovery issues pose great risk where divers need to be deployed. Just gaining access for preliminary investigation tasks may present personnel with complex decisions. During later investigation and recovery, the simple need for a continuing presence may pose a hazard and expose personnel to risk of injury.

3.2.2 ***Fatigue.*** Extended journey times, circadian desynchronisation resulting from transmeridian travel, lengthy working hours and demanding working conditions can result in reduced performance as an outcome of fatigue. These are significant issues about which individuals should be aware and for which they should be prepared. Investigators should ensure they understand the physical and psychological demands of their work and when confronted with particularly demanding working conditions, seek medical advice at an early stage. It is recommended that investigators undergo a periodic medical examination to check their fitness for work at accident sites. Early provisions must be made for nourishment, rest and counselling of investigators both during and following their exposure to the accident site.

3.2.3 ***Insects/wildlife.*** Some sites, particularly in remote areas, will introduce the prospect of exposure to or contact with wildlife. The many insects and larger animals that bite, sting, inject or secrete can cause immediate or long-term health problems, some of which can be life threatening.

3.2.4 ***Climate.*** Extremes of climate are likely to pose problems, especially to unprepared investigators, as can locations where changes in weather can occur suddenly. Even relatively small temperature changes can pose problems where wind and rain may also be involved and work is extended throughout a long day.

3.2.5 ***Security.*** Criminal and terrorist threats are a feature of the social situation in many regions, even in seemingly safe cities. The advice and support of local contacts should be sought to determine security measures that should be adopted. Other political and social advice should be requested in order to not violate local traditions or regulations.

3.3 PHYSICAL HAZARDS

3.3.1 ***Fire and flammable substances.*** Fuel is likely to be one of the most common hazards encountered at a crash site. Fuel poses problems due to its flammability and its nature as a harmful substance. In practice, it is the flammable aspect that most needs to be guarded against. There are, however, other health hazards presented by inhalation of fumes and prolonged skin contact that should also be considered. Where available, the advice of an experienced fire officer attending the site should be sought in guarding against fire hazards and in securing fuel tanks and containers of other flammable liquids such as hydraulic fluids. Fire may also be the result of aircraft batteries short circuiting; this may be caused by impact damage. Prolonged exposure to fire fighting agents can also cause skin and respiratory injuries. These agents should be washed off skin and clothing as soon as possible.

3.3.2 ***Stored energy components.*** Many aircraft structures and systems have the potential to cause injury to personnel. Electrical accumulators or capacitors and emergency power supplies can be hazardous due to their electrical potential and chemical content. Hydraulic accumulators, oleo struts, wheels and fire extinguishing bottles are examples of components that have potential stored energy.

3.3.3 ***Pressurized gases.*** Some pressurized gases are carried onboard aircraft in containers of various designs (see Figure 1). The rapid discharge of these can pose a risk of physical injury or of asphyxiation if released in enclosed spaces. Some fire extinguishing agents can also be toxic. Pressurized oxygen can increase the risk of fire or explosion when released.

3.3.4 ***Military and ex-military aircraft.*** Current and former military aircraft are now commonly flying with civil registration. Civil aircraft crash investigators and emergency responders may, therefore, commonly come into close proximity with cockpit escape equipment and ejector seats and, as a result, be subject to associated hazards.

3.3.5 ***Recent safety equipment.*** Other safety equipment is being introduced into civil aircraft, for example, rocket-deployed emergency parachute systems and airbag restraint systems are being installed across a range of aircraft. Often these systems are not clearly marked and may not be marked at all. The armed and unfired rocket of a rocket-deployed recovery parachute system may pose a potential hazard to investigators and rescue personnel.

Figure 1. A selection of pressurized containers recovered from aircraft accidents

3.3.6 ***Pyrotechnics and explosives.*** Most commercial and many private aircraft carry custom-built explosive charges to initiate escape slides, parachutes, fire extinguishers, cable cutters, flotation gear, deployable emergency locator transmitters, etc. Whilst the activation of these charges may pose only a small direct risk to personnel, the unexpected initiation of the systems that they operate may present a more significant risk. Pyrotechnics are carried by a variety of aircraft and therefore may be discovered amongst the aircraft wreckage. They sometimes sustain impact damage and, as a result, pose an increased risk of initiation. Weapons may also be carried by passengers or crew as cabin or stored baggage and should be carefully treated. In the early stages of the crash investigation, perhaps at the reporting phase, co-ordinating personnel should seek information about any pyrotechnics or explosives known or thought to be on board the crashed aircraft and the information passed to the Investigator-in-charge. These hazards also support the need for adequate police resources to restrict the public and media from access to the accident site for their own protection.

3.3.7 ***Damaged and unstable structures.*** Generally, the hazards posed by damaged aircraft structures will be obvious and most will be readily identified. Situations sometimes arise, however, when persons on site may be exposed to unexpected hazards, for example, if wreckage moves or gives way underfoot. Modern materials, including composite structures, may appear undamaged externally but will have lost structural integrity due to impact and/or heat damage. They can also retain significant energy under the stress of impact, which, when released, may suddenly pose a significant hazard. Structural strength may also be reduced by corrosion, for example, seawater may pose a risk to materials such as magnesium in a relatively short period of time.

3.4 BIOLOGICAL HAZARDS

3.4.1 Accident investigators are at risk of exposure to many biological hazards. Biological hazards may exist in the cockpit, cabin, and cargo wreckage as well as on the ground where bodies and survivors have lain. Since it is not possible to readily identify contaminated blood and other bodily fluids, it is prudent to take precautions whenever working around and in wreckage, when handling wreckage and when performing off-site examinations and tests on wreckage parts.

3.4.2 Precautions must be taken to prevent viruses from entering mucous membranes (such as the eyes, nose and mouth) or non-intact skin such as open cuts or rashes. The accident site may be contaminated with liquid, semi-liquid and dried blood and other bodily fluids, fragmented bones, human or animal tissue and internal organs. In the dried state, there is a risk that particles of these substances may become airborne and come into contact with the unprotected eyes, nose and mouth.

3.4.3 As part of the investigation-planning process, appropriate precautionary measures should be taken against biological hazards. Investigators and others who work on-site, or who carry out off-site examinations and tests of wreckage, should take a biological hazard precaution training course and be inoculated against the Hepatitis B virus. The following procedures should be developed and implemented:

a) a system to maintain records of training and vaccinations;

b) procedures to ensure that the biological hazard area is identified and that precautions are maintained throughout an investigation;

c) procedures for the maintenance of a personal protective equipment inventory;

d) proper methods for donning, removing and disposing of contaminated personal protective equipment;

e) work practices to minimize exposure;

f) procedures for decontaminating investigation equipment and wreckage parts;

g) procedures for shipment of contaminated wreckage parts to off-site examination and test facilities; and

h) procedures to follow when exposure to biological hazards has occurred.

3.4.4 General guidelines on personal protective equipment are contained in Appendix B to Chapter 4 of this Circular. A kit containing personal protective equipment should be made available to each investigator. The kit should include a full cover protective suit, several pairs of latex gloves, work gloves, face masks, goggles, shoe covers and protective boots, disinfection chemicals and a biological hazard disposal bag.

3.4.5 Procedures to be followed at the accident site should include an initial survey for biological hazards in the form of visible blood or other bodily fluids. When there are serious injuries or fatalities, there will often be bodily fluids remaining after the dead and injured are removed. Areas contaminated by spilled blood or bodily fluids should be identified and roped off and have only one point of entry/exit. Only persons using personal protective equipment should be allowed access to the contaminated areas. Any components that are removed from the accident site for examination and testing should be labelled as biohazardous to ensure that they are treated with the same care as exercised at the accident site.

3.4.6 Investigators should always assume that human tissue and bodily fluids are contaminated and, as a minimum precaution, should don a face mask and wear latex gloves under their work gloves when examining wreckage known to contain blood or other fluids. The most common contaminated items include all cabin interior materials, e.g. seat belts/shoulder harnesses, seat cushions, other upholstery and trim materials, and instrument panels. While wearing personal protective equipment in the biological hazard area, investigators should not eat, drink or smoke; apply cosmetics, lip balm or sun block; touch their or others' face, eyes, nose or mouth; neither should they handle contact lenses.

3.4.7 Biological-hazard waste such as clothing and contaminated personal protective equipment should be disposed of appropriately according to local State requirements. Investigators should carefully pull off the outer work gloves first, then peel off the latex gloves and drop both pairs into a biological hazard disposal bag. Contaminated personal protective equipment should never be reused. Exposed skin should be wiped immediately with moist towels, and then washed with soap and water or a solution of one part chlorine bleach to ten parts water. A new bottle of bleach solution should be mixed every day. Contaminated eyes should be flushed with fresh water. Special attention should be given to thorough hand washing after removing latex gloves and before eating, drinking, smoking, or handling contact lenses. Where an investigator or response person suffers an exposure incident involving biological hazards, appropriate and timely medical assessment should be undertaken and any measures indicated by that assessment be taken to ensure the health and well being of the investigator involved.

3.4.8 Investigators should be aware that wearing personal protective equipment in hot and humid climates may result in heat stroke unless precautions are taken to minimize heat stress. Thus, before donning personal protective equipment, a litre or more of water should be consumed. Depending upon the heat and the humidity, and on the amount of physical exertion required, it may be necessary to limit the amount of time that investigators wear personal protective equipment. Once they have left the biological hazard area, removed and disposed of their personal protective equipment and disinfected their hands, investigators should rest in the shade and consume at least a litre of water. It may be necessary to have medical personnel assess the condition of investigators who have experienced heat stress.

3.4.9 Since it is important to minimize the number of investigators, tools and equipment that could come into direct contact with contaminated materials, a minimal number of investigators should be assigned to handle wreckage and disassemble components. Other investigators could be assigned to take notes, draw diagrams, take photographs or use the appropriate manuals and engineering drawings.

3.4.10 Contaminated investigation equipment, such as tools, flashlights and tape measures, should be cleaned with soap and water, disinfected and allowed to dry. Personnel, when leaving the area, should place in biological-hazard disposal bags any equipment that cannot be readily disinfected. On-site garments should be removed at a decontamination area and clean garments worn in transit to prevent biological hazards from being spread to clean areas off the accident site. The disposal bags and their contents are usually incinerated at appropriate facilities, such as hospitals.

3.4.11 ***Local state of hygiene.*** Low levels of hygiene can pose health risks. Even relatively minor complaints can become serious when personnel cannot access medical treatment. Care should be taken when eating and drinking in remote locations or where hygiene levels are of concern. Guidance on essential hygiene should be sought from experts prior to undertaking foreign travel.

3.5 MATERIAL HAZARDS

3.5.1 Damaged aircraft materials can pose health hazards to investigators and search and rescue personnel. Many States are required by national legislation to control the hazards posed by exposure to hazardous substances. This requires the *identification* of hazardous materials found at work, to make an assessment of the associated risks to health, and to put in force suitable measures to control these risks. This is not an easy task as the list of potentially hazardous materials is long. The risk of exposure is highly dependent upon the particular accident profile. Manufacturers and operators are organizations that could assist in compiling lists of materials that may become hazardous when damaged.

3.5.2 Groups of materials that have been considered as hazards to date include:

a) metals and oxides;

b) composite materials;

c) chemicals and other substances; and

d) radioactive materials.

3.5.3 Of these groups, composites have attracted the widest interest in recent times. It is pertinent that they are finding ever wider application and usage in aircraft.

3.5.4 ***Metals and Oxides.*** Many of the metals and their respective oxides are hazardous to health when ingested into the body. However, *all* dusts and particles are considered hazardous when encountered in sufficient concentrations. It requires only relatively small quantities of some metals to pose risks to health and to have a significant effect on the body. These metals and oxides are accordingly classified as high risk. These substances may adversely react with chemicals, such as fire fighting agents, so any indication of chemical reaction should be treated with the greatest care and reported to the Investigator-in-charge.

3.5.5 Traditionally, aircraft structures consist primarily of aluminium alloyed with small amounts of other metals including magnesium, zinc and copper. Advanced materials are under development or are already in use in new metal alloys. The properties of many of these materials, when damaged, are not well understood.

Figure 2. Fire damage to cockpit and avionics

3.5.6 The products of combustion of many materials are hazardous when inhaled, ingested or absorbed and exposure to them is restricted by national safety authorities. In practice, however, due to the type of damage created in an aircraft accident (see Figure 2), it is almost impossible to separately identify and quantify safe limits of exposure to these substances during emergency response and accident investigation activities. Furthermore, accidents in industrial areas may introduce entirely new chemicals that may adversely react with each other or with the aircraft and prove harmful to rescue or investigative personnel.

3.5.7 ***Composite materials.*** The use of fibre-based composites on aircraft is now extensive, with aircraft structures commonly consisting of more than 15 per cent by weight of these materials. A broad range of fibrous materials is used in the construction of composite materials, including carbon, glass, kevlar and boron, with these and others often combined to form a hybrid fibre. The resin matrix binding the fibre generally accounts for around 40 per cent of the manufactured composite material. These different fibres, not surprisingly, behave differently when subjected to the forces and effects of aircraft accidents.

3.5.8 Reports indicate that when subjected to fire or impact alone, composite structures are likely to release around 1 per cent of their base material as free fibres. When subjected to both fire and impact damage, structures can release up to 10-12 per cent of material as free fibres.

3.5.9 Particular concern has been raised about the potential hazard posed by damaged composite structures. Research into these hazards has been conducted at various times following the early use of composites on aircraft, although it is acknowledged that more research on the health hazards posed is required. Research on carbon fibre indicates that this material exhibits minimal fibrogenic activity and little evidence of lung toxicity in tests. The studies show that carbon fibre is different from asbestos and mineral fibre, and less toxic than silica. As a result of recent unrelated research, some States have proposed that all synthetic mineral fibres under 6 microns (mean diameter) should be classified as irritants, and that some ceramic and mineral wools (types generally not used on aircraft) should be classified as carcinogenic (i.e. capable of causing cancer).

3.5.10 Other research suggests that exposure to the dusts of burnt composites may pose more of a problem than exposure to free fibres. What is clear at the present is that more research is required to be sure of the hazards and levels of risk posed by the range of materials.

3.5.11 There are other short term health effects resulting from exposure to the fibres and debris from impacted and combusted composites. Most notably, the fibres are highly irritant, particularly to the eyes, and also to the nose, throat and lungs. There is also still concern that partially burnt debris will cause contact hazards, such as dermatitis. Substances which are taken into the lungs with fibre and dust may also cause sensitization (allergies), which is a significant concern.

3.5.12 As with other hazards, appropriate procedures to limit exposure and reduce disturbance will prevent dusts and fibres from becoming airborne and minimize their hazardous nature when they do. Consideration may be given to entering the accident site from an up-wind direction so hazardous exposure is reduced as much as possible, and if encountered, provides a known exit direction with a reduced risk of further exposure.

3.5.13 ***Chemicals and other substances.*** Aircraft contain many chemical compounds, some which may be hazardous in their natural state and others which can become hazardous when exposed to heat or other substances. For example:

— **Viton** ® is a synthetic rubber-like material containing fluorine used for ‘O’ rings and gaskets in engines and hydraulic systems. If exposed to high temperatures and moisture, the material may degrade and produce a corrosive substance.

— Batteries contain chemicals such as lithium that reacts vigorously with water, and thionyl chloride that decomposes in air to form hydrochloric acid and sulphur dioxide.

— Hydraulic fluids may be hazardous in their normal state, perhaps being classed as irritants. Some also become acidic when exposed to temperatures above a certain threshold.

— Used mineral oils from engines are widely known to be carcinogenic and are identified in specific legislation in some States.

— Partially combusted fuels and lubricants are known to produce a range of hazardous substances.

— Asbestos, although not frequently used in aircraft construction, has been used in heat shielding materials on and around engines and in various gaskets.

3.5.14 ***Radioactive materials.*** Radioactive materials are often used in small volumes in some aircraft components and are frequently carried as cargo in commercial operations, particularly substances for medical use. Generally, specific radioactivities of these are low, and half lives are short. However, higher activity material is regularly carried on-board aircraft. Restrictions on packaging these are, however, very strict, ensuring that in the majority of cases, packaged contents will remain effectively inert in the event of an accident.

— Several radioactive materials have been used in the construction of aircraft. These are mainly materials with a low specific radioactivity, and therefore pose a low risk in their normal state. However, when reduced to dust after fire, they are likely to pose a hazard to health if ingested or inhaled. Depleted uranium has been used in ballast weights for control surfaces in a range of civil and military aircraft. It was fitted in several hundred early versions of the Boeing 747, in Lockheed aircraft, and in stretched versions of the Hercules C130 aircraft. This material has also been used to manufacture tip weights for helicopter main rotor blades.

— Radiologically, depleted uranium is not classed as a significant risk in its undamaged form. Where particulate is produced, however, e.g. by machining or fire damage, depleted uranium may be ingested, inhaled, or absorbed and, once in the body, the material poses a significant chemical hazard.

— *Thorium.* This material has been used extensively in components for aircraft engines, both piston and turbine, and is often alloyed with magnesium, although at relatively low concentrations. It has also been used in other components such as gearbox casings on helicopter and fixed wing aircraft. Its use has been reduced significantly in recent years, however, there are significant stocks of thoriated components available and these are, presumably, still to be used.

— *Tritium.* Beta lights are used extensively on some civil aircraft to indicate emergency exits and also in instrument lights on some military aircraft. Typical beta lights each contain a total of about 20 curies of tritium gas. Exposure to the contents of a single broken beta light could result in a dose of up to 1/10th of the current acceptable annual limit.

— *Other nuclides.* Americium is used in some forward looking infrared (FLIR) systems, Krypton is used within oil level indication systems, and Strontium 90 can be found within ice detection systems and in helicopter rotor crack indicating systems.

3.5.15 ***Cargo***. There are immense difficulties associated with identifying and assessing risks posed by cargo. A huge variety and volume of freight is carried by air, most of which is identified in some way, although a significant volume carries only a general description. Dangerous Goods are usually well identified and documented, and information may be gathered (using dangerous goods manifests) at a very early stage to help determine the degree of hazard. While general cargo, by definition, is considered non-dangerous (in transport classification terms), in general health and safety terms, it is quite capable of posing significant hazards. It should be noted that cargo containing dangerous goods and general cargo may include the chemicals and substances mentioned above. Neither mail, nor private goods, both carried by air in large volumes, carry any indication of contents on their packaging.

3.5.16 When carrying out early site assessment work, it is essential to obtain full information about the complete load of cargo as soon as possible. Dangerous Goods manifests may usually be obtained quickly, but general cargo manifests should also be obtained and reviewed at a very early stage. A wide range of information is contained within manifests/cargo documents, including descriptions of packaging, general description of cargo, and contact details of consignors/consignees, etc.

3.6 PSYCHOLOGICAL HAZARDS

3.6.1 Accident investigations frequently require personnel to work in close proximity to disaster and trauma. This work involves dealing not just with the fatally or seriously injured, but with survivors, relatives and colleagues of the victims. The intensity, scale, and (frequently) long duration of the task can present significant potential for adverse psychological impact on investigation teams. After past disasters, there have been reports of rescue workers suffering from Post-traumatic Stress Disorder (PTSD), causing sleep disturbance, intrusive thoughts and flashbacks. There is little available evidence to confirm such symptoms amongst accident investigators, suggesting that the psychological impact poses less of a risk to investigators than once thought. However, this more satisfactory outcome may be due to the success of existing safety personnel management practices. These include effective selection processes, the establishment of professionalism at both an individual and team level (including good work practices) and effective peer support.

3.6.2 Psychological impact is still a developing area of research for medical teams, and at this time there are varying opinions as to the degree of hazard that it poses. Nevertheless, it is undeniable that some risk is always present and it is recommended that the prospect of some proactive and responsive counselling is incorporated in risk assessments as a precautionary measure to guard against any trauma resulting from the nature of the work. Peer support is particularly valuable because colleagues are likely to quickly recognize personality changes in team members and are in a position to suggest timely counselling. In some Contracting States, it has become practice for management teams to employ the services of counsellors as a matter of course. They may provide immediate assistance to any or all personnel responding to the accident. Counsellors customarily play a passive role, making themselves available to individuals who either seek assistance or are referred for assistance.

Chapter 4

GENERIC OPERATIONAL SAFETY PLANNING GUIDE

INTRODUCTION

To assist with introducing commonality across States, it is recommended that, as a minimum, measures for planning and preparation should include:

— establishing training requirements (occupational health and safety) for investigators, support staff and others who are allowed access to an accident site;

— identifying the Search and Rescue procedures and considerations as published in Annex 12 and applicable local regulations;

— establishing generic plans and procedures including a common risk assessment and site control plan;

— identifying a range of personal protective equipment (PPE) and support equipment; and

— arranging for assistance from specialist advisors should risk management be beyond investigator's knowledge.

Training. Some States are required to provide training to personnel on various health and safety topics. Blood-borne pathogen awareness training is becoming an accepted standard and is being used as an indication of competence for accident site access. Additional recognized training should also be adopted on hazard identification and risk management.

Plans and procedures. The production of a system of generic plans and procedures is likely to have to meet varying national health and safety legislative requirements. Several States have produced comprehensive guidance documents that include a range of plans and procedures. Plans should at least identify the duties and responsibilities of key personnel as well as the actions required at the various stages of response, and should consider the variable nature of accident sites. The introduction of a minimum common format for site risk assessment and control will benefit investigators and other agencies working at site. A typical format for risk assessment is produced at Appendix A. This form should be considered as an initial document and modified to suit local conditions and resource requirements.

Personal Protective Equipment (PPE) and support equipment. Given the variable nature of aircraft accidents and the conditions in which investigators work, it is difficult to produce a definitive list of PPE. However, a generic list is attached at Appendix B for use as guidance, which can be modified to suit the local situation and State policy. Advice should be sought from health and safety specialists to confirm the suitability of any changes or to help identify additional suitable equipment. A wide range of support equipment is often required to ensure that an operating base can be established in any location. Some of this equipment requires special storage conditions in order to maintain its capabilities and prevent degradation of its usefulness.

Specialist assistance. The nature and scale of some accidents may present risk management situations that exceed the knowledge or resources of investigation personnel. It is prudent to have established support arrangements from specialists to advise and assist in areas such as chemical analysis, radiation protection, disposal, trauma management, health and safety management, and personal protective equipment.

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Appendix A to Chapter 4

OPERATIONAL SAFETY PLAN/SITE ASSESSMENT

Use the operational safety plan/site assessment form as a guide to:

— Identify operation name, location and description;

— Identify all operational tasks;

— List identified and anticipated hazards;

— List control measures;

— Identify who will take action and implement control measures;

— List hazardous material/dangerous goods and their containment measures and mitigation options;

— Plan for and identify circumstances that may require emergency termination;

— Plan for emergency procedures and contacts in response to post-accident hazards;

— Identify an off-site administrative unit to provide periodic briefings and to solicit public inquiries so as to minimize non-operational personnel in the accident site;

— Brief personnel on safety plan during pre-op briefing;

— Identify a central administrative point of contact for processing needs of investigators and collecting information on requests for assistance;

— Designate a specific place and time for a daily (or more frequently if required) meeting of all accident site personnel;

— Have a post-op debrief to identify problems, evaluate injuries, and assess coordination with outside agencies;

— Establish post-op panel to modify operational safety plan based upon new recommendations; and

— Keep a copy of form with operational file.

Air Accident Hazards Assessment (Table 1 of 2)

Accident details: ___________________________ **Aircraft:**____

Location: __________________________________ **Assessment date/time:** ________________________________

CATEGORY	HAZARD	IDENTIFIED/CONDITION	LOCATION	CONTROL MEASURES	RISK ACCEPTABLE?
FIRE	Fuel and fuel tanks Flammable fluids Leaking oxygen Leaking or hot batteries Smouldering materials Cutting tools and other heat generating sources Pyrotechnics Hot brakes and tires				
HIGH PRESSURE SYSTEMS	Brakes and tires Hydraulic systems Pneumatic systems Shocks, struts Engine fire bottles				
EXPLOSIVE	Hot brakes and tires Munitions and weapons Ejector seat components Pressurized bottles Rocket-deployed parachute system 'Escape' systems Cartridge-operated devices: weapons pylons, cable cutters, fire bottles, escape systems				
ELECTRICAL	Batteries and systems				
RADIOACTIVE	Weapons and ammunition Structural materials Anti-icing systems Crack indicator systems				

Air Accident Hazards Assessment (Table 2 of 2)

Accident details:___________________________ **Aircraft:**____

Location: ____ **Assessment date/time:** _______________________

CATEGORY	HAZARD	IDENTIFIED/CONDITION	LOCATION	CONTROL MEASURES
A/C RECOVERY	Unequal weight distribution			
BIOLOGICAL	Blood-borne pathogen Poisonous plants Poisonous insects Animals Local health hazards			
SUBSTANCES	Combustion residue Rocket and missile propellant Hydrazine Hazardous cargo Battery acid and gases Smoke and smouldering material			
COMPOSITE MATERIAL	Dust and fibres Sharp edges Shards			
ENVIRONMENT	Heat stress Cold exposure Water hazards Weather Terrain			
MISCELLANEOUS	Damaged and unstable structures Ground installations Security			

EMERGENCY TERMINATION: ____

EMERGENCY PROCEDURES: ____

EMERGENCY CONTACTS:____

PRE-OP BRIEF: (REVIEW THIS PLAN WITH ALL PARTICIPANTS) ______________________________

POST-OP BRIEF: (INCIDENTS, PROBLEMS, OBSERVATIONS) _________________________________

PREPARED BY: ______________________________ DATE: ______________________________

LIST NAMES OF PARTICIPANTS ON REVERSE

KEEP ON OPERATIONAL FILE

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Appendix B to Chapter 4

PERSONAL PROTECTIVE EQUIPMENT

Problems may arise in identifying the most suitable personal protective equipment (PPE) for accident investigation due to conflicting task requirements and varying weather conditions. When setting control measures at the site, PPE should only be introduced after other controls have been considered. These could include the isolation, removal or covering of hazards, suppression of dust and fibres, and restriction of entry to hazardous areas.

Wearing of PPE may pose health and safety hazards due, for example, to heat stress, restriction of visibility, and hampered respiration. Types and specifications of approved PPE vary internationally and personnel should confirm with their specialist advisors the equipment most appropriate to the tasks to be undertaken. Investigators and site-essential experts should be properly trained in the use of this required PPE, and be closely monitored to ensure their safety during the use and disposal of this PPE.

SUGGESTED PROTECTION EQUIPMENT FOR INVESTIGATORS

Investigators should have a prepared PPE kit containing sufficient equipment appropriate to the required duration of work at a particular site. The kit could include:

— Half-face respirator complete with spare set of broad range chemical/dust cartridges (the set should be effective for organic vapour, acid gas and P100). If space permits, a full-face piece respirator complete with spare set of cartridges should be included;

— Several disposable dust/mist HEPA/P3 masks;

— Two or more disposable coveralls;

— Several pairs of disposable nitrile gloves;

— Several pairs of disposable heavy duty gloves;

— One pair of Kevlar cut-resistant gloves with lined palm and fingers;

— Protective footwear with sole and toe protection;

— Hard hat;

— Eye protection: either safety glasses or safety goggles;

— Hearing protection: either ear muffs or ear plugs;

— Hand and equipment wipes;

— High visibility vest;

— Chemical or duct tape.

Other equipment:

- Cleaning/disinfectant chemicals and supplies;
- Bio-disposal bags;
- Drinking water;
- First aid kit;
- Foul-weather clothing;
- Insect protective solutions and medication, if recommended;
- Extra batteries and power supply adaptors for electronic equipment.

Additional equipment for marine environments (this equipment may be specified and supplied by vessel operators):

- Life vest;
- Suitable footwear for deck operations;
- Hard hat or, if permitted, peaked waterproof hat ;
- Pair of neoprene gloves;
- Sun protective screen;
- Motion sickness medication, if recommended.

Chapter 5

HEALTH AND SAFETY TRAINING

5.1 GENERAL

5.1.1 It is acknowledged that many Contracting States will have health and safety training and competency standards that are determined by their own specific legislation for the risks existing within their borders. The aim of this chapter is to identify common training objectives and standards for aircraft accident investigators and support personnel that are recognized and accepted by Contracting States. This will ensure that the health and safety of investigation teams are appropriately supported, and that the entry to the accident site and facilities is not restricted for occupational safety reasons.

5.1.2 The following is recommended as a basis for the minimum syllabus for training courses. Contracting States should review the syllabus to determine whether they wish to add further content to meet the specific needs of their operations. Additional guidance material is provided in Circular 298, *Training Guidelines for Aircraft Accident Investigators.*

5.2 AIMS

5.2.1 Recommended training aims include:

— Detailing the potential variable nature and scale of occupational health hazards experienced at aircraft accident sites;

— Outlining any applicable State occupational health and safety legislation and its applicability to accident investigation activities undertaken by the State's aircraft accident investigators;

— Providing an understanding of the occupational health risk management, risk assessment, and risk control processes associated with aircraft accident investigation operations;

— Provide an understanding of the hazards and means of prevention of exposure to blood-borne pathogens that meets the requirements of State training standards;

— Provide an awareness of the selection and use of personal protective equipment to meet the risks posed in aircraft accident investigation tasks; and

— Provide an awareness of the effects and symptoms of psychological hazards associated with aircraft accident response activities.

5.3 TRAINING CONTENTS

5.3.1 Health and safety training should include the following issues as a minimum:

— Risk management;

— Hazards associated with aircraft accident response;

— Blood-borne pathogens;

— Psychological reactions to aircraft accident response operations;

— Site safety management;

— Preservation of evidence; and

— Protective clothing.

5.4 TRAINER COMPETENCIES

5.4.1 In addition to any training competencies set by Contracting States, it is recommended that training courses include trainers who are knowledgeable and experienced in their subject as it applies to accident site operations. In the case of accident investigation, many of the lessons learned from industry, especially regarding medical waste treatment and dangerous goods transportation, are applicable to aircraft accident investigation and recovery procedures. It is essential that once the investigation is complete at the accident site, the remaining hazards are properly collected and disposed of, and any personal effects from the passengers and crew are returned to them or to their relatives in a timely and humanitarian process.

5.5 TRAINING VALIDITY

5.5.1 Validity periods for some aspects of training may be set by legislation of Contracting States. In addition, research and guidance on hazards is frequently updated. Therefore, it is recommended that hazard awareness training be refreshed every 24 to 36 months, with specific training elements (e.g. blood-borne pathogens) being refreshed at frequencies set nationally. From time to time, experts from medical or manufacturing agencies may require access to the accident site for specific evaluations. These individuals should be accompanied by a qualified investigator to ensure the safety of the visitor and the preservation of the accident site. Government officials, news media and family members should be closely controlled, preferably from inside a vehicle, so as not to interfere with the investigation and to protect them from the various hazards of the site. These tours should not be provided until all medical treatment is provided and any fatalities are removed from the accident site.

5.6 DOCUMENTATION

5.6.1 It is recommended that trained personnel carry evidence of their completion of training courses, including validity periods, and, if desired, details of vaccination status. This may be presented at the accident site to confirm training competency. On-site credentials or access badges should also be provided to identify authorized members, and to ensure accountability of those conducting the investigation. A central check-in and check-out position should be provided with a schedule for periodic reports in order to ensure workers are not injured or lost, especially at remote locations or during adverse weather conditions.

— END —

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